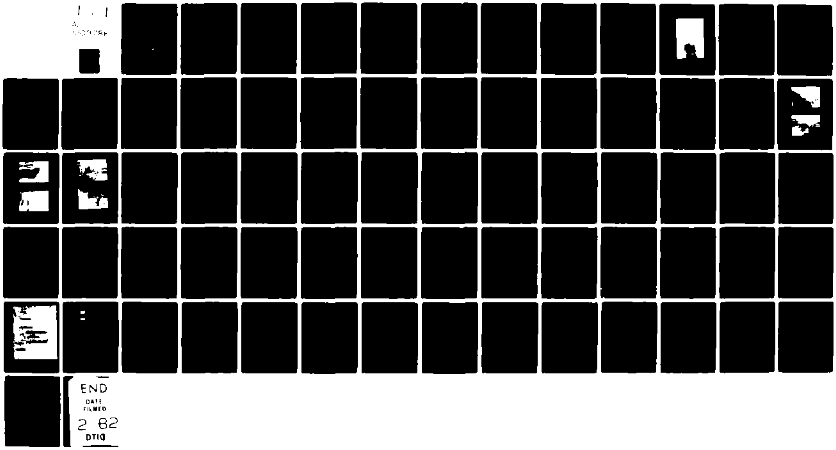
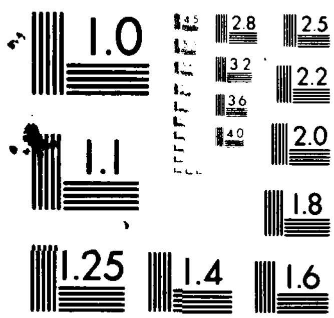
AD-A109 786　D'APPOLONIA CONSULTING ENGINEERS INC PITTSBURGH PA　F/G 13/13
NATIONAL DAM SAFETY PROGRAM. BEEBE LAKE DAM (INVENTORY NUMBER N--ETC(U)
SEP 81　L D ANDERSEN　DACW51-81-C-0011

UNCLASSIFIED　NL





MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

AD A109786

LEVEL II

OSWEGO RIVER BASIN

BEEBE LAKE DAM

TOMPKINS COUNTY, NEW YORK

INVENTORY NO. N.Y.394

PREPARED FOR

NEW YORK DISTRICT CORPS OF ENGINEERS

AUGUST 1981

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER

2. GOVT ACCESSION NO. AD-A109786

3. RECIPIENT'S CATALOG NUMBER

4. TITLE (and Subtitle)
Phase I Inspection Report
Beebe Lake Dam
Oswego River Basin, Tompkins County, NY
Invetory No. 394

5. TYPE OF REPORT & PERIOD COVERED
Phase I Inspection Report
National Dam Safety Program

6. PERFORMING ORG. REPORT NUMBER

7. AUTHOR(s)
LAWRENCE D. ANDERSEN

8. CONTRACT OR GRANT NUMBER(s)
DACW51-81-C-0011

9. PERFORMING ORGANIZATION NAME AND ADDRESS
D'Appolonia Consulting Engineers, Inc.
10 Duff Road
Pittsburgh, PA 15235

10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS

11. CONTROLLING OFFICE NAME AND ADDRESS
Department of the Army
26 Federal Plaza New York District, CofE
New York, New York 10287

12. REPORT DATE
14 September 1981

13. NUMBER OF PAGES

14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)
Department of the Army
26 Federal Plaza New York District, CofE
New York, NY 10287

15. SECURITY CLASS. (of this report)
UNCLASSIFIED

15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; Distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)
Dam Safety
National Dam Safety Program
Visual Inspection
Hydrology, Structural Stability

Beebe Lake Dam
Oswego River Basin
Tompkins County

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report provides information and analysis on the physical condition of the dam as of the report date. Information and analysis are based on visual inspection of the dam by the performing organization.

Based on the evaluation of the existing conditions, the condition of Beebe Lake Dam is considered to be good. The examination of documents and visual observations did not reveal conditions which constitute a hazard to human life or property.

DD FORM 1473 EDITION OF 1 NOV 65 IS OBSOLETE

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

The spillway capacity was evaluated according to the recommended procedure and it was found that the dam can probably pass the required spillway design floods of 50 percent to 100 percent of the Probable Maximum Flood (PMF) without significantly affecting the stability of the main dam, if the dam behaves as an arch structure. Therefore, the spillway capacity is rated as adequate.

Available documents, including a report by the owner, classifies the dam to be a gravity structure. Assuming behavior as a gravity structure, it was found that the factor of safety against overturning, even under normal pool loading conditions, is marginal. No design and construction information is available to document the precise geometry of the dam and whether it was constructed to function as an arch dam. Therefore, it is considered advisable that the owner undertake further investigations to evaluate the stability of the dam.

PREFACE

This report is prepared under guidance contained in the Recommended Guidelines for Safety Inspection of Dams, for Phase I Investigations. Copies of these guidelines may be obtained from the Office of Chief of Engineers, Washington, D.C. 20314. The purpose of a Phase I Investigation is to identify expeditiously those dams which may pose hazards to human life or property. The assessment of the general condition of the dam is based upon available data and visual inspections. Detailed investigation and analyses involving topographic mapping, subsurface investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I Investigation; however, the investigation is intended to identify any need for such studies.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the inspection team. In cases where the reservoir was lowered or drained prior to inspection, such action, while improving the stability and safety of the dam, removes the normal load on the structure and may obscure certain conditions which might otherwise be detectable if inspected under the normal operating environment of the structure.

It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through frequent inspections can unsafe conditions be detected and only through continued care and maintenance can these conditions be prevented or corrected.

Phase I inspections are not intended to provide detailed hydrologic and hydraulic analyses. In accordance with the established Guidelines, the spillway design flood is based on the estimated "Probable Maximum Flood" for the region (greatest reasonably possible storm runoff), or fractions thereof. Because of the magnitude and rarity of such a storm event, a finding that a spillway will not pass the test flood should not be interpreted as necessarily posing a highly inadequate condition. The test flood provides a measure of relative spillway capacity and serves as an aide in determining the need for more detailed hydrologic and hydraulic studies, considering the size of the dam, its general condition and the downstream damage potential.

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
BEEBE LAKE DAM
N.Y. 394
DEC I.D. NO. 75A-691
OSWEGO RIVER BASIN
THOMPKINS COUNTY, NEW YORK

TABLE OF CONTENTS

TABLE OF CONTENTS
(Continued)

TABLE OF CONTENTS
(Continued)

*Not Included due to lack of pertinent data.

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

Name of Dam:	Beebe Lake Dam N.Y. 394
State Located:	New York
County Located:	Thompkins
Stream:	Fall Creek
Date of Inspection:	March 26, 1981 and June 3, 1981

ASSESSMENT

Based on the evaluation of the existing conditions, the condition of Beebe Lake Dam is considered to be good. The examination of documents and visual observations did not reveal conditions which constitute a hazard to human life or property.

The spillway capacity was evaluated according to the recommended procedure and it was found that the dam can probably pass the required spillway design floods of 50 percent to 100 percent of the Probable Maximum Flood (PMF) without significantly affecting the stability of the main dam, if the dam behaves as an arch structure. Therefore, the spillway capacity is rated as adequate.

Available documents, including a report by the owner, classifies the dam to be a gravity structure. Assuming behavior as a gravity structure, it was found that the factor of safety against overturning, even under normal pool loading conditions, is marginal. No design and construction information is available to document the precise geometry of the dam and whether it was constructed to function as an arch dam. Therefore, it is considered advisable that the owner undertake further investigations to evaluate the stability of the dam. An engineering investigation should be undertaken to evaluate in more detail the stability of the dam considering that if the dam behaves as a gravity structure, it does not appear to have adequate resistance to overturning.

The engineering investigation recommended above should commence within 3 to 6 months from final issuance of this report and any remedial work needed as a result of this investigation should be completed within 12 to 18 months from notification of owner. The recommendations below should be implemented within one year from final issuance of this report.

Assessment - Beebe Lake Dam

1. The downstream face of the dam should be inspected under a low flow or nonspill condition to more adequately assess the condition of the structure.

2. Continued periodic inspection of the dam by a professional engineer is recommended.

COMMONWEALTH OF PENNSYLVANIA
REGISTERED PROFESSIONAL
Lawrence D. Andersen
ENGINEER
No. 17458-E

Lawrence D. Andersen, P.E.
Vice President
D'Appolonia Consulting Engineers, Inc.
Pittsburgh, Pennsylvania

Approved by: Col. W. M. Smith, Jr.
New York District Engineer

Date: 14 Sep 81

BEEBE LAKE DAM
N.Y. 394
DEC I.D. 75A-691
MARCH 26, 1981

OVERVIEW

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
BEEBE LAKE DAM
N.Y. 394
DEC I.D. NO. 75A-691
OSWEGO RIVER BASIN
THOMPKINS COUNTY, NEW YORK

SECTION 1: PROJECT INFORMATION

1.1 GENERAL

a. Authority
The Phase I Inspection reported herein was authorized by the Department of the Army, New York District, Corps of Engineers, to fulfill the requirements of the National Dam Inspection Act, Public Law 92-367.

b. Purpose of Inspection
The inspection was to evaluate the existing conditions of the subject dam to identify deficiencies and hazardous conditions, determine if they constitute hazards to life and property, and recommend remedial measures where necessary.

1.2 DESCRIPTION OF PROJECT

a. Dam and Appurtenances
The Beebe Lake Dam is a concrete structure with a maximum height of 26 feet from the downstream toe. The dam consists of a central arch overflow section flanked by a nonoverflow section on the left (looking downstream) and secondary overflow sections on the right.

Very limited design and construction information is available for the dam. To the extent that can be determined from available information, the crest length of the main overflow section is about 145 feet. The two secondary overflow sections, with crest lengths of about 75 feet and 35 feet, are located to the right of the main overflow section. The crests of the secondary overflow sections are about six inches and two feet, respectively, above the crest of the main dam. The left nonoverflow section includes the intake facilities for an abandoned hydraulic laboratory facility below the dam. The abandoned facilities include a waterwheel immediately downstream of the dam and a penstock leading to the abandoned laboratory. Photograph 2 in Appendix A shows the facilities described above. Photograph 3 shows the intake house located at the right abutment of the dam for the hydroelectric facilities.

Available records indicate the typical cross section of the main dam to be approximately triangular, with a base width of 18 feet and structural height of 26 feet at the maximum section. The

downstream face of the dam is stepped, apparently to dissipate the energy of overflowing water. The records also indicate that the dam was constructed immediately downstream from an existing stone masonry dam which was left in place. The space between the new dam and the existing dam was filled with clay.

The two overflow sections of the dam constitute the spillway facilities. Other discharge facilities include a primary low level outlet incorporated into the main dam and a secondary low level outlet in the nonoverflow section. The main low level outlet facility is reported to be nonfunctional. The low level outlet in the nonoverflow section consists of a 48-inch-square sluice gate. The lake can be lowered by approximately 18 feet through this outlet.

b. Location

The dam is located on Fall Creek within the city limits of Ithaca in Thompkins County, New York. Plate 1 illustrates the location of the dam.

c. Size Classification

The dam is classified as small, based on the 26-foot height and normal pool storage capacity of 93 acre-feet.

d. Hazard Classification

The dam is classified to be in the high hazard category. Below the dam, Fall Creek flows through a narrow, deep gorge and enters the valley of Cayuga Lake, approximately one-half mile downstream from the dam. In the remaining 1.5-mile reach, the stream initially flows through residential areas and then discharges into Cayuga Lake. In this reach, the stream flows under State Route 34.

Based on visual observations, it is estimated that failure of the dam would cause loss of more than a few lives and appreciable property damage in the residential areas below the dam.

e. Ownership

The dam is owned and operated by Cornell University. (Address: Mr. Henry Doney, Director of Utilities, Humphrey Building, Cornell University, Ithaca, New York 14853, 607-256-4727).

f. Purpose of Dam

The purpose of the dam is water supply, recreation and hydropower.

g. Design and Construction History

The dam was designed by Cornell University in 1897, and construction was completed in 1900.

h. Normal Operating Procedure

The reservoir is normally maintained at or above the crest level of the overflow sections of the dam at Elevation 780.6 (USGS Datum).

1.3 PERTINENT DATA

Elevations referred to in this section and subsequent sections of the report were obtained from the available drawings of the dam.

a. Drainage Area (sq. mi.)	128.4
b. Discharge at Dam (cfs)	
Spillway at top of nonoverflow section	5700 ±
Reservoir drain (sluice gate opening)	Unknown[(1)]
c. Elevation (USGS Datum) (feet)	
Top of dam (overflow section)	780.6
Top of dam (nonoverflow section)	784.7
d. Reservoir (acres)	
Surface area at top of overflow section	20
Surface area at top of nonoverflow section	22 ±
e. Storage Capacity (acre-feet)	
Top of dam (overflow section)	93
Top of dam (nonoverflow section)	180 ±
f. Dam	
Type	Concrete gravity/arch
Length	145 feet
Height	26 feet
Top width	6 ± feet
Side slopes	Downstream: 1H:1.5V Upstream: Vertical
Cutoff	Unknown
Grout curtain	No
g. Primary Spillway	
Type	Three concrete overflow sections
Length (total)	225 feet
Crest elevations	780.6, 781 and 782.5[(2)]
h. Reservoir Drain	
Type	48-inch sluice gate
Length	Unknown
Access	Not accessible
Regulating facility	Electrically operated sluice gate hoist

[(1)] Operable sluice gate discharges into the conduit located through the left abutment. No design information is available to determine the capacity of this low level outlet facility.

[(2)] See Plate 2 for layout of the overflow sections.

SECTION 2: ENGINEERING DATA

2.1 DATA AVAILABLE

Available information was obtained from New York State Department of Environmental Conservation, Dam Safety Division files, and from the files of Cornell University. Available information includes limited drawings and past inspection reports and an emergency action plan for the dam.

2.2 GEOLOGY

The Beebe Lake Dam is located in the glaciated Allegheny Plateau section of the Appalachian Plateau Province. This region is characterized as a maturely dissected plateau with the topographic features modified by continental glaciation. The modification consists of rounding off of the high areas and deposition of glacial till in the valleys.

The dam site is located just north of a large northeast trending anticline (trending approximately north 70 degrees east). The folding is gentle with a maximum dip on the limbs of one to two degrees. The dip of the strata is affected locally by the folding; however, regionally, the rock strata dip south to southwest at approximately 100 to 150 feet per mile. The most prominent fracture orientations in the region have a strike of north 20 degrees west with a vertical dip. A secondary fracture trace strikes north 60 to 65 degrees east and is vertical, while less prominent fractures strike north 80 west and north 15 degrees east and are vertical. A prominent north 50 degrees east linear trends through the dam.

The rock strata in the area consist of unconsolidated Pleistocene glacial till (Wisconson Drift) underlain by strata of the Genesee Group (Upper Devonian Age). The glacial till consists of a mixture of clay and silt with varying quantities of gravel. The glacial till is relatively thin on hilltops and slopes and thicker in the valleys. The bedrock consists of a thick sequence of interbedded gray to black shale, fissile black shale, brown-gray argillaceous limestone, gray siltstone occasionally calcereous, brownish-black petroliferous shale, brown sandstone, silty mudstone, and cross-laminated siltstone. In addition, there are several north-south trending kimberlite and alnoite dikes in the vicinity of the dam. These intrusions are Jurassic to Lower Cretaceous in age (approximately 145 to 150 million years old).

2.3 SUBSURFACE INVESTIGATION

The available information includes no reference to a subsurface investigation.

2.4 EMBANKMENT AND APPURTENANT STRUCTURES

As noted before, very limited information is available on the design and construction of the dam. Sketches in Plate 2 illustrate the plan view and typical cross section of the main nonoverflow section as derived from the available information. As shown in Plate 2, the dam was constructed immediately downstream from an existing masonry dam and the space between the existing and the new dam was filled with clay. The main overflow section is approximately triangular in cross section, with a base width of 18 feet and a structural height of 26 feet at the maximum section. The downstream face was stepped, apparently for the purpose of dissipating the energy of falling water. References were found to indicate that a cutoff trench was excavated at the base of the main embankment. However, no reference was found to indicate the extent and nature of the cutoff trench.

The functioning low level outlet facility for the dam consists of a four-foot-square sluiceway located in the left abutment nonoverflow section. The flow through this outlet facility is controlled by a sluice gate located on the upstream face of the dam. The sluice gate is operated by a portable electric motor.

Available data include no reference to hydrologic, hydraulic, or stability analyses used to design the dam.

2.5 CONSTRUCTION RECORDS

No construction records are available. The available records indicate the dam is essentially the same as originally constructed and no major postconstruction changes were instituted.

2.6 OPERATING RECORDS

No operating records are maintained. Stream flow records are available from a USGS stream gaging station located approximately one-half mile upstream from the dam.

2.7 EVALUATION OF DATA

The information obtained from the state and Cornell University files is considered to be adequate for Phase I inspection purposes.

SECTION 3: VISUAL INSPECTION

3.1 FINDINGS

a. General

Visual inspections of the dam were conducted on March 26 and June 3, 1981. On both dates, the pool level was approximately six inches above the crest of the overflow section.

b. Dam

No identifiable signs of distress or misalignment were observed. However, it should be noted that because the major portion of the dam is an overflow section and waterfalls are located immediately below the toe of dam, the dam could not be closely inspected. The dam was observed from vantage points approximately 100 to 150 feet from the dam along the abutments.

Some minor structural cracks were observed on the downstream side of the nonoverflow section near the left abutment. Plate 2 illustrates the locations of these observations. To the extent visible through falling water, horizontal crack-like features were observed on the downstream face of the main dam. It is possible that deteriorating concrete at horizontal construction joints could be causing this appearance. It is considered advisable that the downstream face of the dam be more closely inspected during low flow periods to assess the nature of these features.

c. Spillway

The dam constitutes the spillway of the dam.

d. Reservoir Drain

A four-foot-square sluiceway located on the left abutment nonoverflow section constitutes the main low level outlet facility for the dam. Flow through this sluiceway is controlled by a sluice gate located on the upstream face. The invert of the sluice gate is located approximately 18.5 feet below the overflow crest level. The sluice gate was operated by Cornell University personnel and observed to be functional.

e. Downstream Channel

The stream channel below the dam is a deep gorge. The channel appears to be stable in the near vicinity of the dam.

f. Reservoir

It appears that the reservoir is silted to within several feet of the spillway overflow section. There are sediment islands within the reservoir approximately 100 to 200 feet upstream from the dam. Cornell University personnel reported that plans are being considered to dredge the reservoir.

3.2 EVALUATION

The dam was found to be in good condition. However, as noted before, the dam can only be inspected from vantage points 100 to 150 feet away from the dam. A closer inspection of the downstream portion of the dam during low flow or nonspill conditions is considered to be advisable.

SECTION 4: OPERATION AND MAINTENANCE PROCEDURES

4.1 PROCEDURES

The reservoir is normally maintained at the crest level of the dam with excess inflow discharging over the dam. The dam has no formal operating procedure.

4.2 MAINTENANCE OF THE DAM

The dam is maintained by Cornell University. The maintenance condition of the dam is considered to be satisfactory.

4.3 WARNING SYSTEM IN EFFECT

A formal emergency action plan, prepared at the request of the Federal Energy Regulatory Commission, defines the course of action to be followed by the operators of the dam in the event of an emergency and constitutes the warning system in effect.

4.4 EVALUATION

The maintenance condition of the dam is considered to be good. However, as mentioned previously, closer inspection of the downstream face of the dam during low flow conditions is considered to be advisable.

SECTION 5: HYDRAULIC/HYDROLOGY

5.1 DRAINAGE AREA CHARACTERISTICS

Beebe Lake Dam has a watershed of 128.4 square miles. The stream falls approximately 1,000 feet from its headwaters about 10 miles northwest of Cortland, New York, to Beebe Lake at approximate Elevation 780. The watershed is predominantly covered with woodland and pastureland. Representative relief ranges between gentle to moderate.

5.2 ANALYSIS CRITERIA

As previously stated, Beebe Lake Dam is classified as a small dam in the high hazard category. Under the recommended criteria for evaluating emergency spillway discharge capacity, such impoundments are required to pass one-half to full PMF.

The PMF inflow hydrograph for the reservoir was determined using the Dam Safety Version of the HEC-1 computer program developed by the Hydrologic Engineering Center of the U.S. Army Corps of Engineers. The data used for the computer input are presented in Appendix D.

5.3 SPILLWAY CAPACITY

The spillway facilities consist of the overflow sections of the dam. The discharge capacity of the overflow sections of the dam, without overtopping the left abutment nonoverflow section, is estimated to be about 5700 cfs. The spillway capacity was calculated assuming the overflow sections to be critical flow control sections.

5.4 RESERVOIR CAPACITY

The dam impounds a reservoir with a storage capacity of about 93 acre-feet at the spillway crest level and about 180 acre-feet at the nonoverflow crest level.

5.5 FLOODS OF RECORD

According to the USGS stream gage records, maximum flow in Fall Creek occurred on July 8, 1935, when the discharge was 15,500 cfs.

5.6 OVERTOPPING POTENTIAL

The PMF inflow hydrograph, determined according to the recommended procedure, was found to have a peak flow of about 76,000 cfs. The 50 percent PMF peak flow is 38,000 cfs. Various percentages of PMF inflow were routed through the reservoir and the dam was found to

pass less than 10 percent of the PMF without overtopping the nonoverflow section on the left abutment (Elevation 784.7). During the passage of 50 percent and 100 percent of the PMF, depths of flow over the spillway would be about 12 and 18 feet, respectively.

5.7 EVALUATION

The results of a preliminary stability analysis, which is discussed in Section 6, indicate that the dam would be stable during the passage of full PMF; therefore, the spillway capacity is classified to be adequate according to the recommended criteria. However, as discussed in Section 6, a detailed evaluation of the stability of the dam is advisable, considering that if the dam behaves as a gravity structure without arch action, it does not appear to have adequate resistance to overturning.

SECTION 6: STRUCTURAL STABILITY

6.1 EVALUATION OF STRUCTURAL STABILITY

a. Visual Observations

As discussed in Section 3, the field observations did not reveal signs of distress that would significantly affect the stability of the dam at this time. However, it was noted that the downstream face of the dam was obscured by falling water and the toe is not accessible for close inspection of the dam. Therefore, closer inspection of the dam under low flow or nonspill conditions was advised.

b. Design and Construction Data

Available information does not include any design calculations, design drawings or construction data to aid in the assessment of the structural stability of the dam.

c. Stability Analysis

In a report entitled Project No. 3251-NY Emergency Action Plan prepared by Cornell University, dated December 12, 1980, the dam is described to be a "monolithic concrete gravity dam." A preliminary stability analysis assuming the dam to be a gravity structure approximately triangular in cross section with a base width of 18 feet and structural height of 26 feet and using normal pool hydrostatic and silt loading, shows the dam to be only marginally stable. The following table summarizes the results of the preliminary stability analysis.

Loading Condition	Location of Resultant from Toe	Sliding Factor of Safety
Normal pool + silt loading	4.7 feet	Greater than 4
50 percent PMF	Outside of base	Less than 1 (by inspection)

Location of the middle one-third of the base is 6 to 12 feet from the downstream toe.

A further preliminary stability analysis, considering arch action in the main overflow section of the dam, is included in Appendix G. The results indicate that with consideration of arch action, the dam is likely to be stable under full PMF loading conditions. This arch analysis can only be considered as a first order approximation of the behavior of the dam because it is not clear that proper construction procedures and details were followed to attain an arch action. Also, no construction drawings are available to provide the precise geometry of the dam.

In view of the above concerns, it is considered advisable that the owner undertake further detailed investigations to evaluate the stability of the dam considering that if the dam behaves as a gravity structure, it does not appear to have adequate resistance to overturning.

d. Postconstruction Changes
No postconstruction changes are reported.

e. Seismic Stability
The dam is located in Seismic Zone 1. Based on the recommended criteria for evaluation of seismic stability of dams, the structure is presumed to present no hazard from earthquakes.

SECTION 7: ASSESSMENT/RECOMMENDATIONS

7.1 ASSESSMENT

a. Safety

Visual observations indicate that Beebe Lake Dam is in good condition. No conditions were observed that would significantly affect the overall performance of the structure at this time. However, as previously noted, the main dam is an overflow section and falling water obscures the dam. Further, the toe of the dam is not accessible for closer inspection.

The spillway capacity was evaluated according to the recommended procedure and it was found that the dam can probably pass the required spillway design floods of 50 percent to 100 percent of the PMF without significantly affecting the stability of the main dam, if the dam behaves as an arch structure. Therefore, the spillway capacity is rated as adequate. However, available documents, including a report by the owner, classifies the dam to be a gravity structure. Assuming behavior as a gravity structure only, it was found that the factor of safety against overturning, even under normal pool loading conditions, is marginal. No design and construction information is available to document the precise geometry of the dam and whether it was constructed to function as an arch dam. Therefore, it is considered advisable that the owner undertake further investigations to evaluate the stability of the dam.

b. Adequacy of Information

Available information, in conjunction with visual observations, is considered to be sufficient to make a Phase I evaluation.

c. Need for Additional Investigations

Closer inspection of the downstream face of the dam during low flow or nonspill conditions is considered to be advisable. Also, an engineering investigation should be undertaken to evaluate in more detail the stability of the dam, considering that if the dam behaves as a gravity structure without arch action, it does not appear to have adequate resistance to overturning.

d. Urgency

The recommended engineering investigation should commence within 3 to 6 months from final issuance of this report and any remedial work needed as a result of this investigation should be completed within 12 to 18 months from notification of owner. The subsequent recommendations should be implemented within one year from final issuance of this report.

7.2 RECOMMENDATIONS

1. An engineering investigation should be undertaken to evaluate in more detail the stability of the dam considering that if the dam behaves as a gravity structure, it does not appear to have adequate resistance to overturning.

2. The downstream face of the dam should be inspected under a low flow or nonspill condition to more adequately assess the condition of the structure.

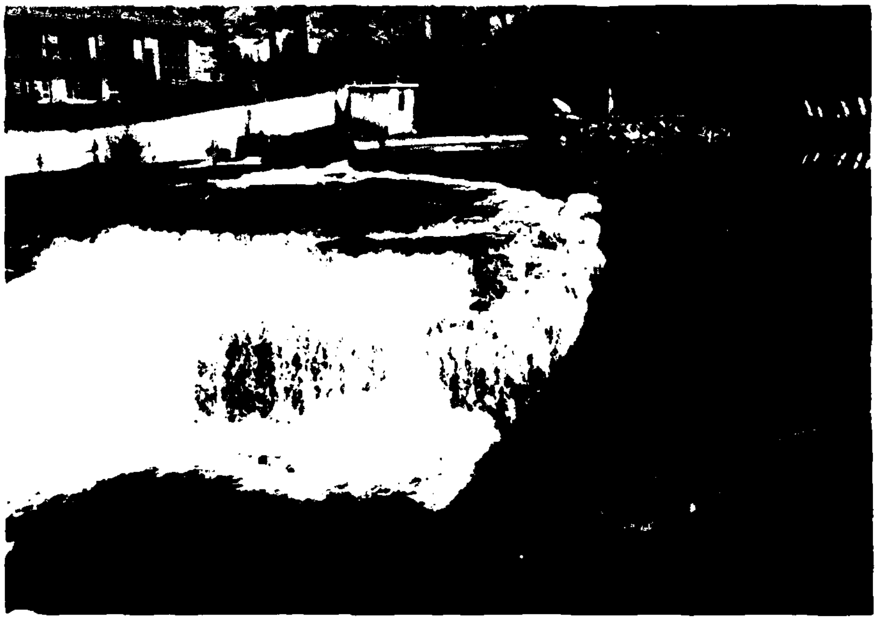
3. Continued periodic inspection of the dam by a professional engineer is recommended.

APPENDIX A

PHOTOGRAPHS

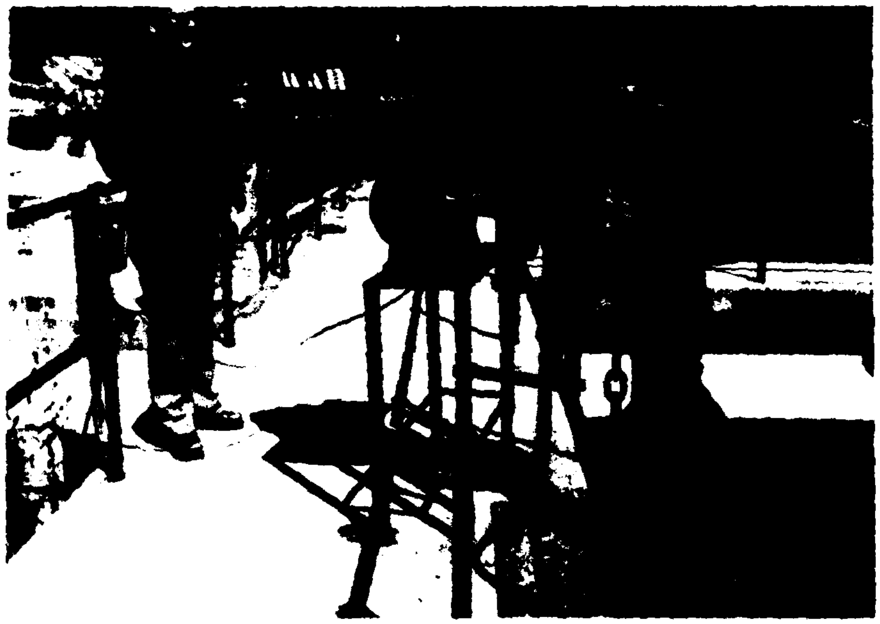
PHOTOGRAPH NO. 1
Dam (looking east)

PHOTOGRAPH NO. 2
Left Abutment (looking southeast)



PHOTOGRAPH NO. 3
Right Abutment (looking north)

PHOTOGRAPH NO. 4
Dam Crest



PHOTOGRAPH NO. 5
Left Abutment Low Level Outlet
Sluice Gate Hoist and Motor

PHOTOGRAPH NO. 6
Falls Creek Through Ithaca
(1.5 miles downstream)

APPENDIX B

VISUAL INSPECTION CHECKLIST

APPENDIX B
VISUAL INSPECTION CHECKLIST

1) Basic Data

a. General

Name of Dam Beebe Lake Dam

Fed. I.D. # N.Y. 394 DEC Dam No. 75A-691

River Basin Oswego

Location: Ithaca

Stream Name Falls Creek

Tributary of Cayuga Lake

Latitude (N) 42° 27.1' Longitude (W) 76° 28.8'

Type of Dam Concrete Arch/Gravity

Hazard Category High

Date(s) of Inspection March 26, 1981 and June 3, 1981

Weather Conditions Sunny, Temp. 40 degrees

Reservoir Level at Time of Inspection About six inches over spillway crest Elevation 781 ±

b. Inspection Personnel Lawrence Andersen, P.E.; James Poellot, P.E.; Bilgin Erel, P.E.; and Wah-Tak Chan, P.E.

c. Persons Contacted (Including Address & Phone No.) Mr. Merrit E. Howtz, Associate Director of Plant Operations, Department of Utilities, Cornell University, Ithaca, New York 14853, (607) 256-4727

d. History:

Date Constructed 1897 Date(s) Reconstructed N/A

Designer Cornell University

Constructed by Unknown

Owner Cornell University

2) Embankment

a. Characteristics

(1) Embankment Material Concrete

(2) Cutoff Type Unknown

(3) Impervious Core N/A

(4) Internal Drainage System N/A

(5) Miscellaneous --

b. Crest

(1) Vertical Alignment N/A

(2) Horizontal Alignment N/A

(3) Surface Cracks N/A

(4) Miscellaneous N/A

c. Upstream Slope

(1) Slope (Estimate) N/A

(2) Undesirable Growth or Debris, Animal Burrows N/A

(3) Sloughing, Subsidence or Depressions N/A

(4) Slope Protection N/A

(5) Surface Cracks or Movement at Toe N/A

d. Downstream Slope

(1) Slope (Estimate) N/A

(2) Undesirable Growth or Debris, Animal Burrows N/A

(3) Sloughing, Subsidence or Depressions N/A

(4) Surface Cracks or Movement at Toe N/A

(5) Seepage N/A

(6) External Drainage System (Ditches, Trenches, Blanket)

N/A

(7) Condition Around Outlet Structure N/A

(8) Seepage Beyond Toe Unknown

e. Abutments - Embankment Contact

Not accessible for inspection.

(1) Erosion at Contact Unknown

(2) Seepage Along Contact Unknown

3) <u>Drainage System</u>

a. Description of System N/A

b. Condition of System N/A

c. Discharge from Drainage System N/A

4) <u>Instrumentation</u> (Monumentation/Surveys, Observation Wells, Weirs, Piezometers, etc.)

None

5) Reservoir

a. Slopes Steep, no problems observed.

b. Sedimentation Sediment appears to be within 5 to 6 feet of overflow crest.

c. Unusual Conditions Which Affect Dam None

6) Area Downstream of Dam

a. Downstream Hazard (No. of Homes, Highways, etc.) Residential area about 1.5 miles downstream.

b. Seepage, Unusual Growth N/A

c. Evidence of Movement Beyond Toe of Dam N/A

d. Condition of Downstream Channel Deep gorge. Appears to be stable in the near vicinity of the dam.

7) Spillway(s) (Including Discharge Conveyance Channel)

Overflow sections of the dam constitute the spillway facilities.

a. General Main Overflow: Generally satisfactory (cannot be closely inspected).

Auxiliary Spillway: N/A

b. Condition of Service Spillway See note above.

c. Condition of Auxiliary Spillway N/A

d. Condition of Discharge Conveyance Channel N/A

8) Reservoir Drain/Outlet

Type: Pipe ____ Conduit ____ Other Sluice Opening

Material: Concrete X Metal ____ Other ____

Size: 46-inch x 46-inch Length Unknown

Invert Elevations: Entrance 760± Exit 740± (estimated)

Physical Condition (Describe): Submerged, not visible.

Material: Appears to be concrete.

Joints: N/A Alignment Unknown

Structural Integrity: Unknown

Hydraulic Capability: Unknown

Means of Control: Gate X Valve ____ Uncontrolled ____

Operation: Operable X Inoperable ____ Other ____

Present Condition (Describe): Operated by Cornell University personnel, observed to be functional.

9) Structural

a. Concrete Surfaces Visible surfaces are in satisfactory condition. Face of the dam cannot be closely inspected because of overflow.

b. Structural Cracking Some minor cracking on the left non-overflow section. Horizontal looks like fractures on the face of the dam.

c. Movement - Horizontal & Vertical Alignment (Settlement) No preceivable misalignments.

d. Junctions with Abutments or Embankments Dam abutment junctions not accessible for inspection.

e. Drains - Foundation, Joint, Face The dam reportedly incorporates no drains.

f. Water Passages, Conduits, Sluices Not accessible for inspection, submerged.

g. Seepage or Leakage Cannot be identified. The entire dam is an overflow structure. Thus, water overflowing the dam precluded inspection.

h. Joints - Construction, etc. Not visible.

i. Foundation Not accessible for inspection.

j. Abutments Not accessible for inspection.

k. Control Gates Main dam level outlet sluice gate reported to be nonfunctional.

l. Approach & Outlet Channels Approach channel: Beebe Lake is settled. There are sediment islands within 100 to 200 feet of the dam.

m. Energy Dissipators (Plunge Pool, etc.) None

n. Intake Structures None

o. Stability No visually identifiable distress.

p. Miscellaneous None

10) Appurtenant Structures (Power House, Lock, Gatehouse, Other)

a. Description and Condition There is an abandoned waterwheel downstream of the left abutment nonoverflow section.

APPENDIX C

ENGINEERING DATA CHECKLIST

APPENDIX C

ENGINEERING DATA CHECKLIST

NAME OF DAM: BEEBE LAKE DAM

AREA-CAPACITY DATA:

	Elevation (feet)	Surface Area (acres)	Storage Capacity (acre-feet)
1) Top of Dam	784.6	22	180 ±
2) Design High Water (Max. Design Pool)	N/A	N/A	N/A
3) Auxiliary Spillway Crest	N/A	N/A	N/A
4) Service Spillway Crest	780.6	20	93
5) Crest of Orifice (Normal Pool)	N/A	N/A	N/A

DISCHARGES

	Discharge (cfs)
1) Average Daily	180
2) Spillway at Maximum High Water (Top of Dam)	5700
3) Spillway at Design High Water	Unknown
4) Principal Spillway at Dam Crest Elevation	N/A
5) Low Level Outlet	300 ± (estimated)
6) Total of All Facilities at Maximum High Water (Top of Dam)	6000
7) Maximum Known Flood	15,500
8) At Time of Inspection	200 ±

DAM: Beebe Lake Dam

CREST ELEVATION: 784.7

Type: Concrete Arch/Gravity

Width: 6 ± feet Length: 145 feet (main overflow)

Spillover: The dam is an overflow structure.

Location: Center of the dam.

SPILLWAY:

SERVICE		AUXILIARY
780.6	Elevation	N/A
Concrete overflow	Type	N/A
145 feet (main overflow)	Width	N/A
	Type of Control	
Uncontrolled	Uncontrolled	N/A
	Controlled	
N/A	Type (Flashboards; Gate)	N/A
N/A	Number	N/A
N/A	Size/Length	N/A
	Invert Material	N/A
	Anticipated Length of Operating Service	N/A
N/A	Chute Length	N/A
5 to 6 feet	Height Between Spillway Crest and Approach Channel Invert (Weir Flow)	N/A

Hydrometerological Gages:

Type: USGS stream flow gage.

Location: One-half mile upstream of the dam.

Records:

Date - July 8, 1935

Max. Reading - 15,500 cfs

FLOODWATER CONTROL SYSTEM:

Warning System: None

Method of Controlled Releases (Mechanisms):

None

DRAINAGE AREA: 128.4 square miles

DRAINAGE BASIN RUNOFF CHARACTERISTICS:

Land Use - Type: Predominantly woodlands

Terrain - Relief: Moderate

Surface - Soil: Unknown

Runoff Potential (existing or planned extensive alterations to existing surface or subsurface conditions)

Drainage area is large. Development is not likely to affect runoff in foreseeable future.

Potential Sedimentation Problem Areas (natural or man-made; present or future)

The lake is silted within 5 to 6 feet of the dam crest. There are sediment islands within the lake.

Potential Backwater Problem Areas for Levels at Maximum Storage Capacity Including Surcharge Storage:

None

Dikes - Floodwalls (overflow and nonoverflow) - Low Reaches Along the Reservoir Perimeter:

Location: None

Elevation: N/A

Reservoir:

Length at Maximum Pool: 2,000± feet

Length of Shoreline at Normal Pool: 5,000± feet

APPENDIX D

HYDROLOGY AND HYDRAULIC ANALYSES

HYDROLOGY AND HYDRAULIC ANALYSIS
DATA BASE

NAME OF DAM: Beebe Lake Dam (NY DEC 75A-691)

PROBABLE MAXIMUM PRECIPITATION (PMP) = 21.0 INCHES/24 HOURS[1]

STATION	1	2	3	4	5
Station Description	Beebe Lake	Beebe Lake Dam			
Drainage Area (square miles)	128.4	-			
Cumulative Drainage Area (square miles)	128.4	128.4			
Adjustment of PMF for Drainage Area (%)					
6 Hours	81	-			
12 Hours	95	-			
24 Hours	106	-			
48 Hours	112	-			
72 Hours	-	-			
Snyder Hydrograph Parameters					
C_p/C_t [2]	0.77/2.16	-			
L (miles)[3]	30.0	-			
L_{ca} (miles)[3]	17.7	-			
$t_p = C_t(L \cdot L_{ca})^{0.3}$ (hours)	14.11	-			
Spillway Data					
Crest Length (ft)	-	145.0			
Freeboard (ft)	-	4.0			
Discharge Coefficient	-	3.1			
Exponent	-	1.5			

(1) Hydrometeorological Report 33 (Figure 1), U.S. Army, Corps of Engineers, 1956.
(2) Snyder's Coefficients.
(3) L = Length of longest water course from outlet to basin divide.
L_{ca} = Length of water course from outlet to point opposite the centroid of drainage area.

```
*********************************
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION      JULY 1978
  LAST MODIFICATION  01 APR 80
*********************************
     1             A1      SNYDER UNIT HYDROGRAPH, SPILLWAY AND DAM OVERTOPPING ANALYSES
     2             A2      BEEBE LAKE DAM (NY 691)TOMPKINS COUNTY,N.Y. PROJECT NO. 80-778-07
     3             A3      FOR 7%,10%,20%,30%,40%,50%,60%,80%,AND 100% PROBABLE MAXIMUM FLOOD(PMF)
     4             B    300       2       0       0       0       0       0       0      -4       0
     5             B1     5
     6             J      1       9       1
     7             J1  0.07    0.10    0.20    0.30    0.40    0.50    0.60    0.80    1.00
     8             K      0       1                                       1
     9             K1      CALC. OF SNYDER INFLOW HYDROGRAPH TO BEEBE LAKE DAM, (N.Y. 691)
    10             M      1       1   128.4           128.4                                   1
    11             P           21.0      81      95     106     112
    12             T                                                    1.0    0.05              0.0003
    13             W   14.1    0.77
    14             X   -1.5   -0.05     2.0
    15             K      1       2                                       1
    16             K1      ROUTING FLOW THROUGH BEEBE LAKE DAM, (NY 691)
    17             Y                              1       1
    18             Y1     1                                          -780.6      -1
    19             Y4 780.6   780.8   781.0   781.5   782.0   782.5   783.0   783.5   784.0   784.5
    20             Y4 785.0   786.0   787.0   788.0   789.0   790.0   792.0   794.0   797.0   800.0
    21             Y5   0.0    40.2   113.7   466.0   977.1  1604.4  2367.2  3247.4  4225.5  5291.3
    22             Y56437.6  8950.4 11730.6 14754.0 18002.2 21460.6 28960.9 37178.0 50724.5 65627.4
    23             $A  20.0    23.9    38.6    43.2    48.7
    24             $E 780.6   790.0   800.0   810.0   820.0
    25             $$ 780.6
    26             $D 784.7     3.1     1.5   100.0
    27             K     99
```

COMPUTER INPUT OVERTOPPING ANALYSIS

PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
AREA IN SQUARE MILES (SQUARE KILOMETERS)

OPERATION	STATION	AREA	PLAN	RATIO 1 .07	RATIO 2 .10	RATIO 3 .20	RATIO 4 .30	RATIO 5 .40	RATIO 6 .50	RATIO 7 .60	RATIO 8 .80	RATIO 9 1.00
				RATIOS APPLIED TO FLOWS								
HYDROGRAPH AT	1	128.40	1	5316.	7595.	15189.	22784.	30379.	37973.	45568.	60758.	75947.
		(332.55)		(150.54)(	215.06)(	430.12)(	645.17)(	860.23)(	1075.29)(	1290.35)(	1720.46)(	2150.58)
ROUTED TO	2	128.40	1	5314.	7590.	15181.	22784.	30363.	37958.	45539.	60748.	75913.
		(332.55)		(150.47)(	214.92)(	429.88)(	645.16)(	859.79)(	1074.85)(	1289.52)(	1720.18)(	2149.61)

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1 ....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	780.60	780.60	784.70
STORAGE	0.	0.	85.
OUTFLOW	0.	0.	5750.

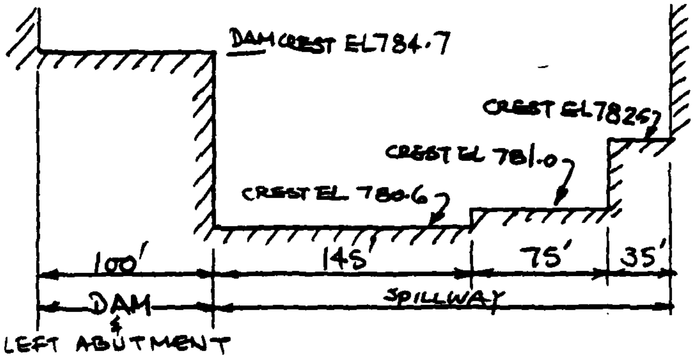
RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.07	784.51	0.00	81.	5314.	0.00	52.00	0.00
.10	785.39	.69	100.	7590.	10.00	52.00	0.00
.20	787.63	2.93	151.	15181.	20.00	52.00	0.00
.30	789.45	4.75	193.	22784.	26.00	52.00	0.00
.40	791.05	6.35	232.	30363.	28.00	52.00	0.00
.50	792.54	7.84	271.	37958.	32.00	52.00	0.00
.60	793.92	9.22	310.	45539.	34.00	52.00	0.00
.80	796.45	11.75	389.	60748.	36.00	52.00	0.00
1.00	798.78	14.08	470.	75913.	40.00	52.00	0.00

OVERTOPPING ANALYSIS SUMMARY

D'APPOLONIA
CONSULTING ENGINEERS, INC.

By WTC Date 8/17/81 Subject Beeke Dam Sheet No. 1 of 1
Chkd. By BE Date 8/28/81 SPILLWAY CAPACITY RATING Proj. No. 80-778

SPILLWAY RATING



SCALE:
VERT. 1" = 4'
HORI 1" = 100'

PROFILE OF DAM AND SPILLWAY CREST
(LOOKING D/S)

SPILLWAY CAPACITY

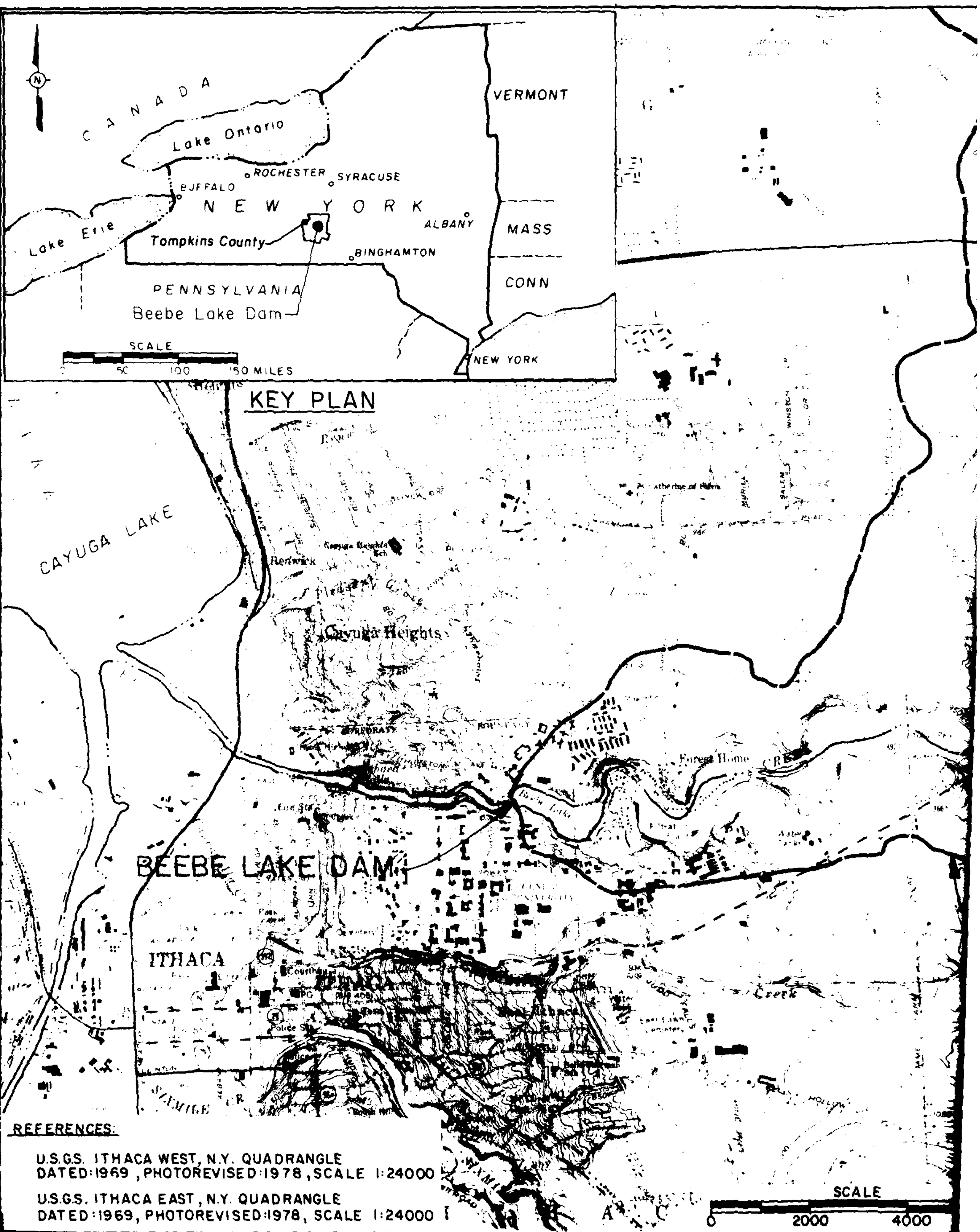
$$Q_S = \Sigma \left[C L H^{1.5} \right]$$

$$= (3.1)\left[(145)(W.L. EL - 780.6)^{1.5} + (75)(W.L. EL\ 781.0)^{1.5} + (35)(W.L. EL\ 782.5)^{1.5}\right]$$

LAKE ELEVATION	Q_s L=145'	Q_s L=75'	Q_s L=35'	COMBINED SPILLWAY CAPACITY	LAKE ELEVATION	Q_s L=145'	Q_s L=75'	Q_s L=35'	COMBINED SPILLWAY CAPACITY
	cfs	cfs	cfs	cfs		cfs	cfs	cfs	cfs
780.6	0	—	—	0	785.0	4148.7	1860.0	428.9	6437.6
780.8	40.2	—	—	40.2	786.0	5640.5	2599.4	710.4	8950.4
781.0	113.7	0	—	113.7	787.0	7277.8	3417.0	1035.7	11730.6
781.5	383.8	32.2	—	466.0	788.0	9048.5	4306.0	1399.5	14754.0
782.0	744.6	232.5	—	977.1	789.0	10943.3	5260.9	1798.0	18002.2
782.5	1177.2	427.1	0	1604.4	790.0	12954.5	6277.5	2228.5	21460.
783.0	1671.3	657.6	38.4	2367.2	792.0	17301.6	8482.3	3177.0	28960.
783.5	2219.9	919.0	108.5	3247.4	794.0	22048.9	10897.8	4231.3	37178.
784.0	2818.0	1208.1	199.3	4225.5	797.0	29853.5	14880.0	5990.8	50724.
784.5	3462.0	1522.4	306.9	5291.3	800.0	38408.9	19255.4	7943.0	65607.

APPENDIX E

PLATES



KEY PLAN

REFERENCES:

U.S.G.S. ITHACA WEST, N.Y. QUADRANGLE
DATED: 1969, PHOTOREVISED: 1978, SCALE 1:24000

U.S.G.S. ITHACA EAST, N.Y. QUADRANGLE
DATED: 1969, PHOTOREVISED: 1978, SCALE 1:24000

DRAWN BY	CHECKED BY	APPROVED BY	DRAWING NUMBER
Ars 7-14-81	BE 7/22/81	7-21-81	80-778-B35

19 1253 HERCULENE. A&B SMITH CO. PGH. PA LT1530-1079

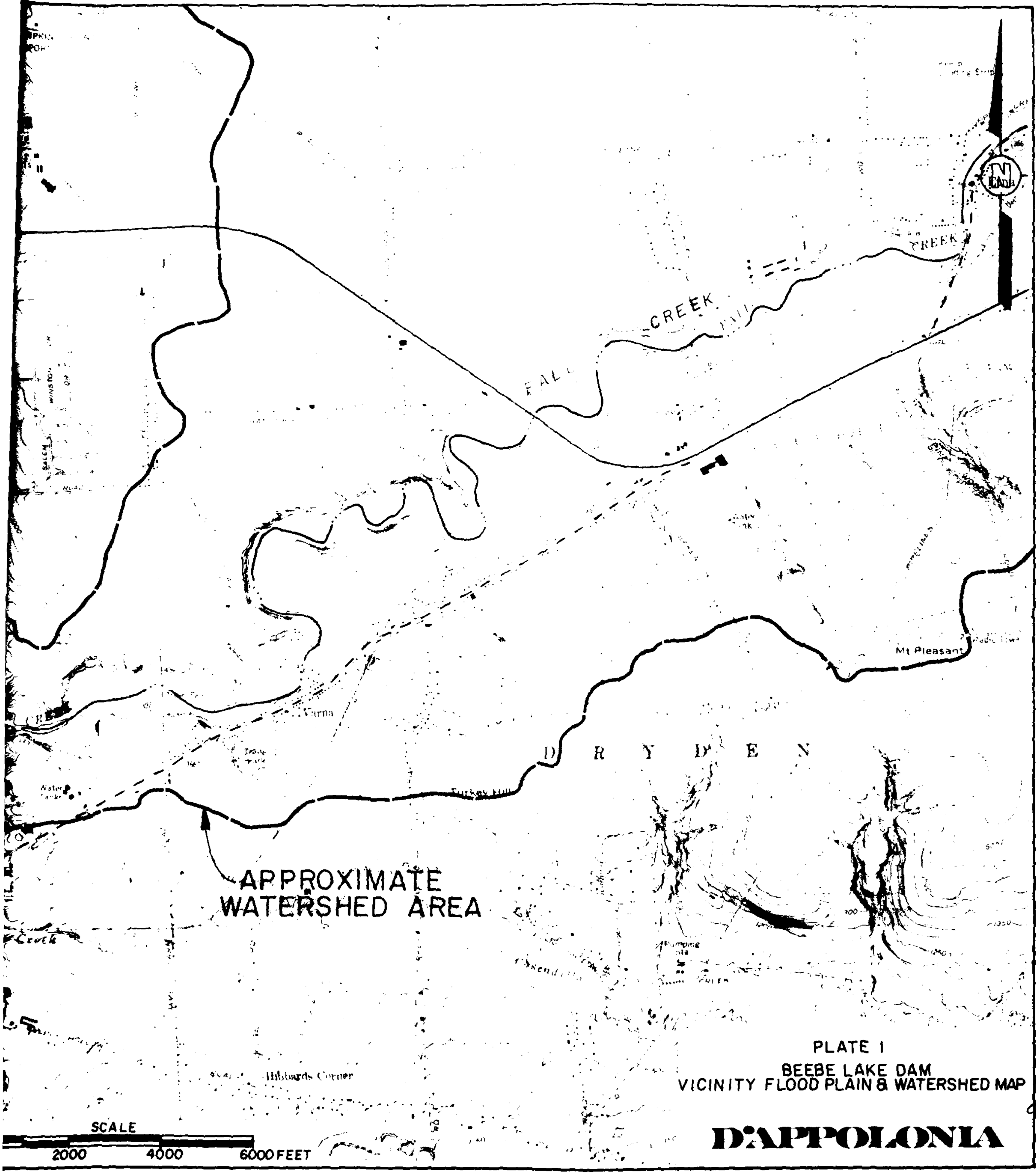


PLATE I
BEEBE LAKE DAM
VICINITY FLOOD PLAIN & WATERSHED MAP

D'APPOLONIA

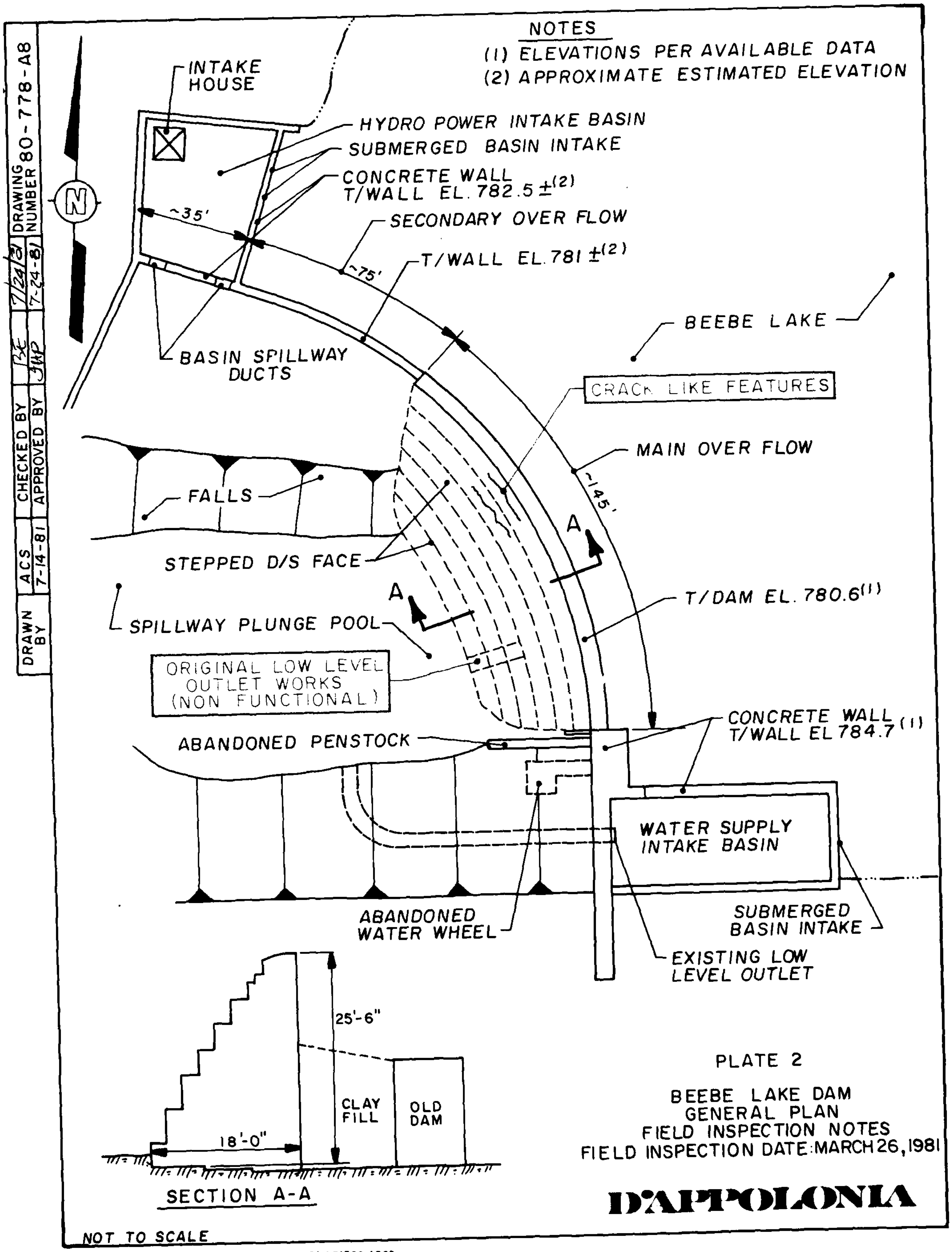


PLATE 2

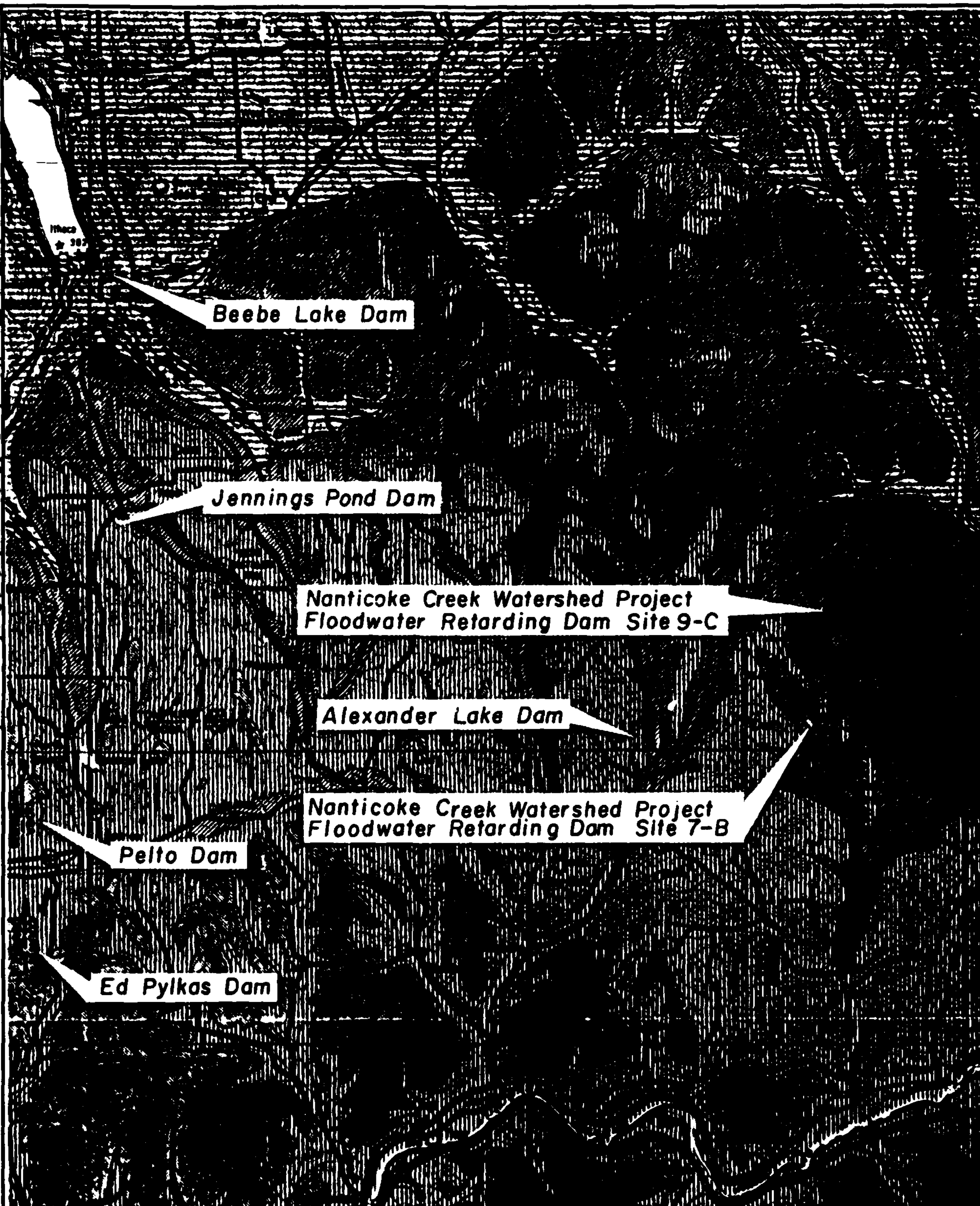
BEEBE LAKE DAM
GENERAL PLAN
FIELD INSPECTION NOTES
FIELD INSPECTION DATE: MARCH 26, 1981

D'APPOLONIA

APPENDIX F

GEOLOGY MAP

DRAWN BY ACS 4-29-81 | CHECKED BY TSC 5/7/81 | APPROVED BY JHP 5-7-81 | DRAWING NUMBER 80-778-A3



SCALE

0 2 4 6 8 10 miles

GEOLOGY MAP

REFERENCE.

GEOLOGIC MAP OF NEW YORK, FINGER LAKES SHEET
DATED 1970, SCALE 1 250,000

D'APPOLONIA

LEGEND

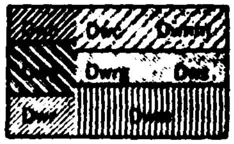
CANADAWAY GROUP
800-1200 ft. (240-370 m.)

Dcv Machias Formation—shale, siltstone; Rushford Sandstone; Caneadea, Canisteo, and Hume Shales; Canaseraga Sandstone; South Wales and Dunkirk Shales; In Pennsylvania: Towanda Formation—shale, sandstone.

JAVA GROUP
300-700 ft. (90-210 m.)

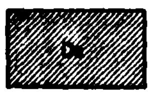
Dj Wiscoy Formation—sandstone, shale; Hanover and Pipe Creek Shales.

WEST FALLS GROUP
1100-1600 ft. (340-490 m.)



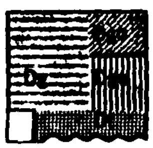
Dwn Nunda Formation—sandstone, shale.
Dwg West Hill and Gardeau Formations—shale, siltstone; Roricks Glen Shale; upper Beers Hill Shale; Grimes Siltstone.
Dwr lower Beers Hill Shale; Dunn Hill, Millport, and Moreland Shales.
Dwc Nunda Formation—sandstone, shale; West Hill Formation—shale, siltstone; Corning Shale.
Dwnm "New Milford" Formation—sandstone, shale.
Dwg Gardeau Formation—shale, siltstone; Roricks Glen Shale.
Dw Slide Mountain Formation—sandstone, shale, conglomerate.
Dwm Beers Hill Shale; Grimes Siltstone; Dunn Hill, Millport, and Moreland Shales

SONYEA GROUP
200-1000 ft. (60-300 m.)



Ds In west: Cashaqua and Middlesex Shales.
In east: Rye Point Shale; Rock Stream ("Enfield") Siltstone; Pulteney, Sawmill Creek, Johns Creek, and Montour Shales.

GENESEE GROUP AND TULLY LIMESTONE
200-1000 ft. (60-300 m.)



Dg West River Shale; Genundewa Limestone; Penn Yan and Geneseo Shales; all except Geneseo replaced eastwardly by Ithaca Formation—shale, siltstone and Sherburne Siltstone.
Dgo Oneonta Formation—shale, sandstone.
Dgu Unadilla Formation—shale, siltstone.
Dt Tully Limestone.

LOCKPORT GROUP
80-175 ft. (25-55 m.)

Sl Oak Orchard and Penfield Dolostones, both replaced eastwardly by Sconondoa Formation—limestone, dolostone.

GEOLOGY MAP LEGEND

REFERENCE
GEOLOGIC MAP OF NEW YORK, FINGER LAKES SHEET
DATED: 1970, SCALE 1:250,000

D'APPOLONIA

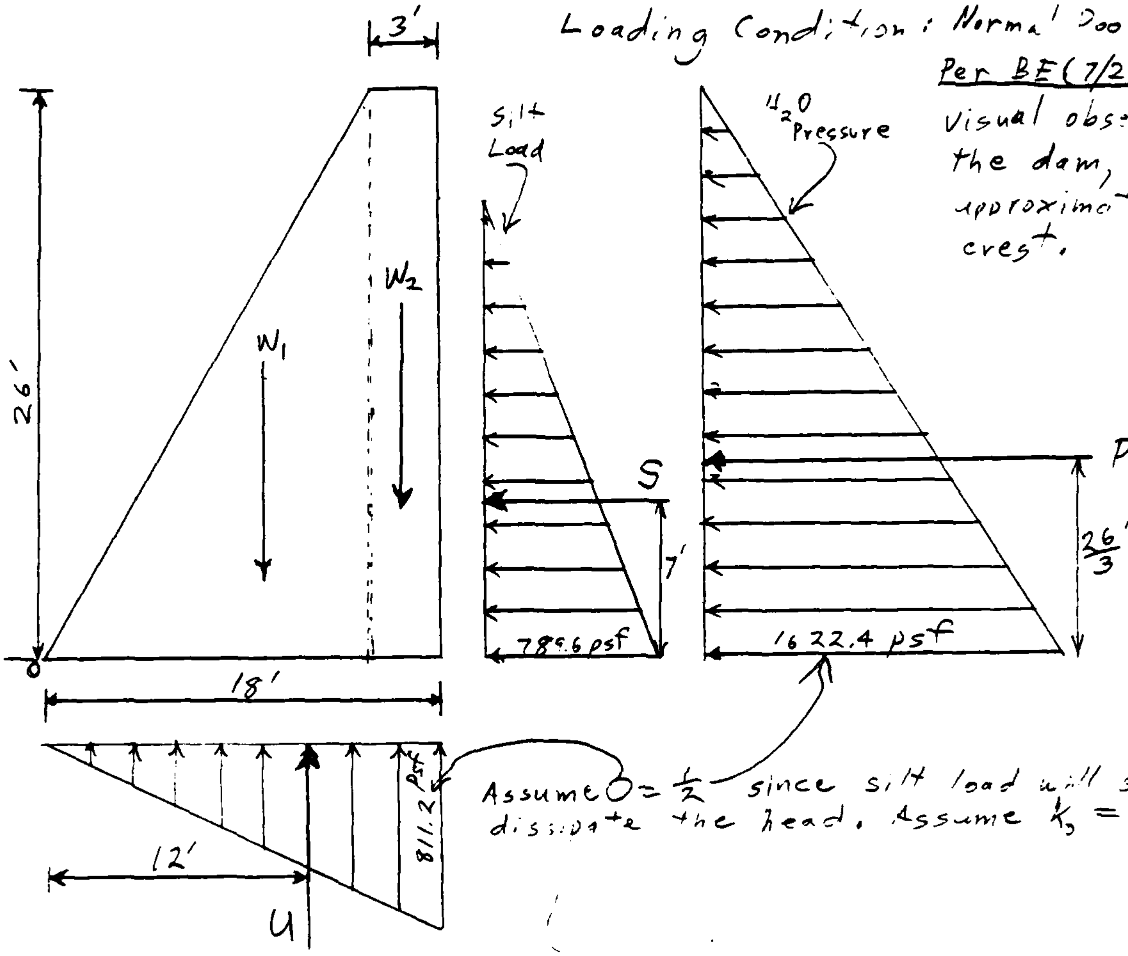
DRAWN BY	ACS 4-29-81	CHECKED BY	5/7/81	DRAWING NUMBER 80-778-A6
		APPROVED BY JHD	5-7-81	

APPENDIX G

STABILITY ANALYSES

Loading Condition: Normal Pool + Silt

Per BE (7/28/81): From visual observations of the dam, silt exists to approximately 5' from the crest.



Assume θ = ½ since silt load will serve to dissipate the head. Assume $K_0 = 1.0$

Typical values of the unit weight of loose silt (J. E. Bowles, 1979, Physical & Geotechnical Properties of Soils, p. [illegible], McGraw-Hill) are

14.0 – 15.5 kN/m³ ≈ 90 – 100 pcf, → Assume γ_{SAT} = 100 pcf

→ $\gamma_{Bouyant}$ = 100.0 − 62.4 = 37.6 pcf.

U = 811.2 (18) ½ = 7300.8 lb/ft. W_1 = 15/2 (26) [illegible] = [illegible]
S = K_0 γ_B (21.0)(21) ½ = 8290.8 lb/ft. W_2 = 3. [illegible] = [illegible]
P = (1622.4)(26) ½ = 21091.2 lb/ft.

D'APPOLONIA
CONSULTING ENGINEERS, INC.

By J.A.E. Date 7/28/81 Subject BEEBE LAKE DAM Sheet No. 2 of 2
Chkd. By BE Date 9/4/81 STABILITY CALCULATIONS Proj. No. 80-778

$$\curvearrowleft \Sigma M_o = 10\,W_1 + 16.5\,W_2 - 12\,U - 7\cdot S - \tfrac{26}{3}P$$

$$= 10(29250) + 16.5(11700) - 12(7300.8) - 7(8290.8) - \tfrac{26}{3}(21091.2)$$

$$= 157{,}114 \text{ ft.-lb.} \Rightarrow e = \frac{\Sigma M_o}{\Sigma V} = \frac{157{,}114}{(29250+11700-7300.8)} = 4.7 < 6.0$$

$\longrightarrow$ Resultant is outside middle 1/3 portion of the base therefore, dam may be unstable.

- Check Sliding Stability

From Table 1, EM 1110-2-2200 (9/25/58), Loading Condition II

$$\Sigma H/\Sigma V \text{ (Max)} = 0.65$$

$$\rightarrow \Sigma H = P + S = 21091.2 + 8290.8 = 29382.0 \text{ lb}$$
$$\Sigma V = W_1 + W_2 - U = 29250 + 11700 - 7300.8 = 33649.2 \text{ lb}$$

$$\rightarrow \Sigma H/\Sigma V = \frac{29382.0}{33649.2} = 0.87 > 0.65$$

Foundation is composed of limestone, siltstone, and shale. Typical lower bound strength parameters for these materials are: limestone, $\phi = 56^\circ$, $c = 1100$ psi; siltstone, $\phi = 57^\circ$, $c = 750$ psi; shale, (Cucaracha shale) $\phi = 38^\circ$, $c = 45$ psi. {From ETL 1110-2-184, 2-25-74}
$(\tan\phi)_{Avg} = (\tan 56^\circ + \tan 57^\circ + \tan 38^\circ)/3 = 3.80/3 = 1.27 \rightarrow \bar{\phi} = \underline{51.7^\circ}$
$\bar{c} = (1100 + 750 + 45)/3 \approx 632$ psi. / $S_{concrete} = 2\sqrt{f'_c} \approx 110$ psi (3000 psi concrete)

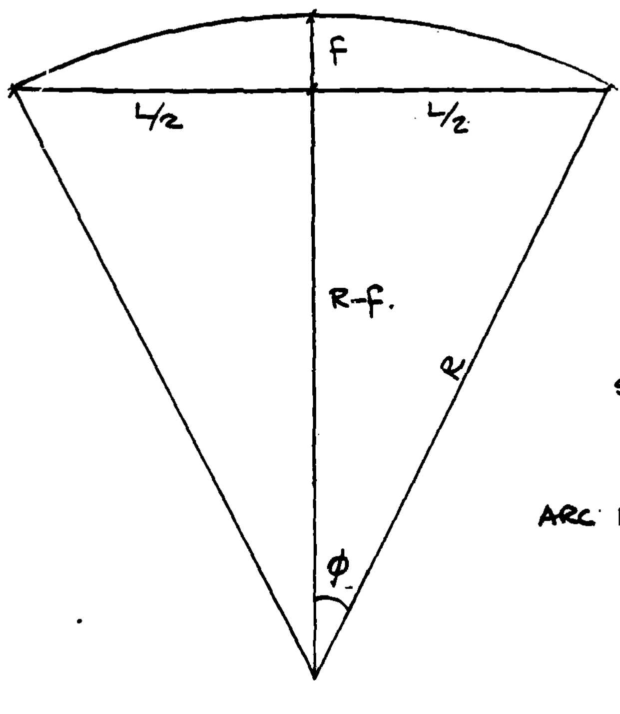
$$S_{(S\text{-}F)} = \frac{f\,\Sigma V + 0.5(s)A}{\Sigma H}\ ;\quad A = 18' \times 1' = 18 \text{ ft}^2,\ S = S_{concrete} = 110 \text{ psi.}\quad f = \tan\bar{\phi} = 1.27$$

$$\rightarrow S_{(SF)} = \frac{1.27(33649.2) + 0.5(110)(18.0 \times 144 \text{ in}^2)}{29382.0} = \frac{185224}{29382} \approx \underline{\underline{6.3 \geq 4.0}}$$

$\rightarrow$ sliding is OK.

ARCH DAM ANALYSIS

THE GEOMETRIC DATA SHOWN BELOW FOR THE MAIN OVERFLOW SECTION OF THE BEEBE DAM WAS SCALED FROM POST-CONSTRUCTION DRAWING OF THE DAM IS THEREFORE APPROXIMATE. THE DRAWINGS WERE OBTAINED FROM CORNELL UNIVERSITY FILES.



SCALE FROM DRAWINGS:-
L = 136'
f = 16'
ARC LENGTH = 145'

CALCULATE RADIUS:

$$R^2 = \overline{L/2}^2 + (\overline{R-f})^2 = \frac{L^2}{4} + R^2 - 2Rf + f^2$$

$$R = \frac{1}{2f}\left(\frac{L^2}{4} + f^2\right) = \frac{1}{2\times16}\left(\frac{\overline{136}^2}{4} + \overline{16}^2\right) = \underline{152.5' = R}$$

D'APPOLONIA
CONSULTING ENGINEERS, INC.

By BE Date 7-24-81 Subject BEEBE LAKE DAM Sheet No. 2 of 8
Chkd. By JAG Date 8/5/81 STABILITY CALCULATIONS Proj. No. 80-778

ARCH ANGLE ϕ

$$\sin \phi = \frac{L/2}{R} = \frac{L}{2R} = \frac{136}{2 \times 152.5} = 0.446$$

$$\phi = \sin^{-1}(0.446) = 26.5^\circ = 0.46 \text{ RAD.}$$

BACK CALCULATE ARC LENGTH

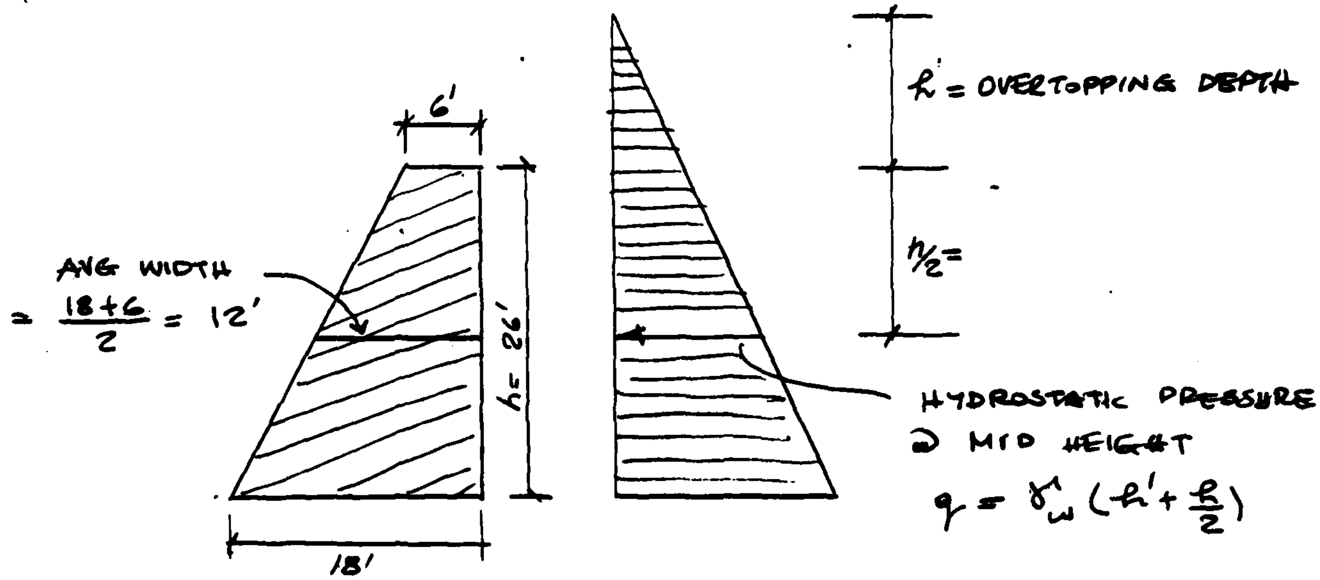
$$\text{ARC LENGTH} = \frac{2\phi}{360} \cdot 2\pi R$$

$$= \frac{2 \times 26.5}{360} \, 2\pi \times 152.5$$

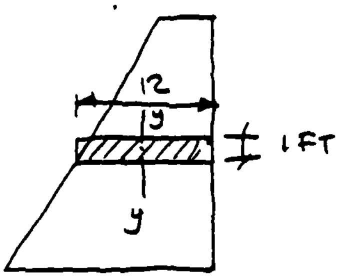
$$= 141 \text{ ft} \approx 145' \text{ SCALED LENGTH}$$

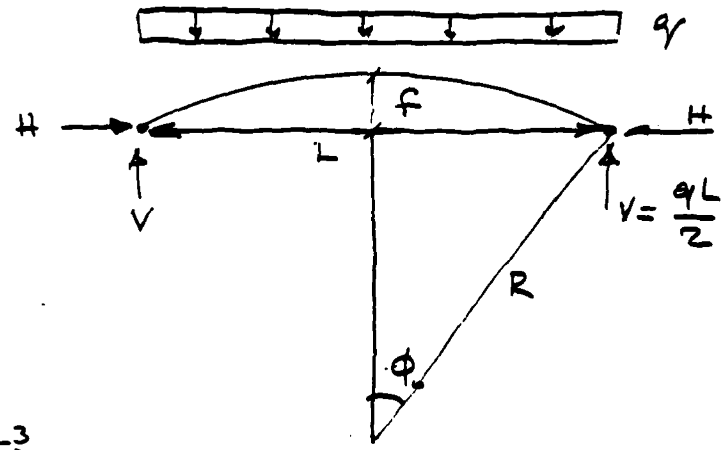
$\therefore$ CALCULATED RADIUS & ϕ VALUES ok.

TYPICAL X-SECTION OF DAM & HYDROSTATIC LOADING:-



CHECK ARCH STRESS @ MID HEIGHT OF DAM





SLICE AREA $= 144\,(12 \times 1)$
$= 1728 \text{ in}^2$

$$I_{y-y} = \frac{b\ell^3}{12} = \frac{(1 \times 12) \times (12 \times 12)^3}{12}$$
$$= 3 \times 10^6 \text{ in}^4$$

$R = 152.5' = 1830''$

$$H = \frac{\overbrace{\int M'_x\, y \,\frac{ds}{EI}}^{A} - \overbrace{\int P'_s \,\frac{dz}{EA}}^{B}}{\underbrace{\int y^2 \, ds/EI}_{C} - \underbrace{\int \left(\frac{dz}{ds}\right) dz/EA}_{D}} \qquad \text{REF (1)}$$

WHERE

$$A = \frac{qR^4}{I}\left(\frac{2}{3}\sin^3\phi_0 - \phi_0 \cos\phi \sin^2\phi + \frac{1}{2}\phi_0 \cos\phi_0 - \frac{1}{2}\sin\phi \cos^2\phi_0\right)$$

$$B = \frac{2qR^2}{3A}\left(\sin^3\phi\right)$$

REF (1) STRUCTURAL ANALYSIS FOR ENGINEERS by N. WILLEMS & W. M LUCAS JR McGRAW HILL 1978

D'APPOLONIA
CONSULTING ENGINEERS, INC.

By BE Date 7-24-81 Subject ~~BEEBE~~ LAKE DAM Sheet No. 4 of 8
Chkd. By JAE Date 8/5/81 STABILITY CALCULATIONS Proj. No. 80-778

$$C = \frac{R^3}{I}\left(\phi_0 + 2\phi_0 \cos^2\phi_0 - 3\sin\phi_0\cos\phi_0\right) \quad \left(\frac{1}{in}\right)$$

$$D = \frac{R}{A}\left(\phi_0 + \sin\phi\cos\phi\right) \quad \left(\frac{1}{in}\right)$$

FROM PG 1 $\phi_0 = 26.5^\circ = 0.463$ rad.

$\therefore \sin\phi_0 = 0.446$ $\quad (R = 1830")$
$\cos\phi_0 = 0.895$

$$\therefore A = \frac{q\,(\overline{1830})^4}{3\times10^6}\left(\frac{2}{3}\underbrace{(\overline{0.446})^3}_{0.059} - \underbrace{0.463\times0.895\times\overline{0.446}^2}_{0.082} + \frac{1}{2}\underbrace{0.463\times0.895}_{0.207} - \frac{1}{2}\underbrace{0.446\times\overline{0.895}^2}_{0.179}\right)$$

$$= 3.74\times10^6\,(0.059 - \underbrace{0.082 + 0.207}_{0.005} - 0.179) = 1.87\times10^4\,q$$

$$B = \frac{2\times\overline{1830}^2}{3\times1728}\,q\,(\overline{0.446}^3) = 1.14\times10^2\,q = 0.001\times10^4\,q$$

$$C = \frac{\overline{1830}^3}{3\times10^6}\left(0.463 + 2\underbrace{\times0.463\times\overline{0.895}^2}_{0.742} - 3\times\underbrace{0.446\times0.895}_{1.198}\right)$$

$$= 2.04\times10^3\,(0.463 \overbrace{+\,0.742}^{0.007} - 1.198) = \underline{14.30\,q}$$

$$D = \frac{1830}{1728}\,(\overbrace{0.463 + 0.446\underbrace{\times0.895}_{0.399}}^{0.862}) = 0.91\,q$$

$$\therefore H = \frac{1.87\times10^4 - 0.001\times10^4}{14.30 - 0.91}\,q = \underline{\underline{1397\,q}}\ (in)$$

FROM HEC-1 COMPUTER PROGRAM OUTPUT OVERTOPPING DEPTH @ 100 % PMF IS ≈ 17 FT (SEE APPENDIX D)

∴ HYDROSTATIC PRESSURE @ MID HEIGHT OF DAM

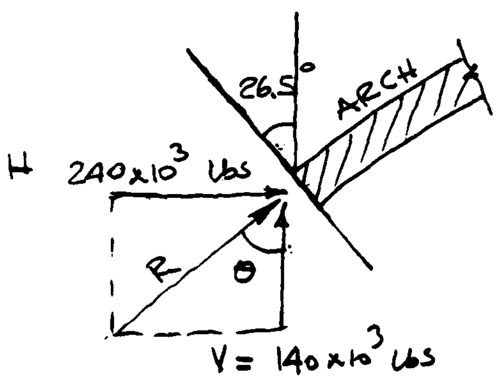
$$p = \gamma_w \left(17 + \frac{26}{2}\right) = 1872 \text{ psf} \qquad \gamma_w = 62.4 \text{ lb/ft}^3$$

LOADING PER INCH ARC LENGTH $= \frac{1872}{12} = 156$ lbs/in

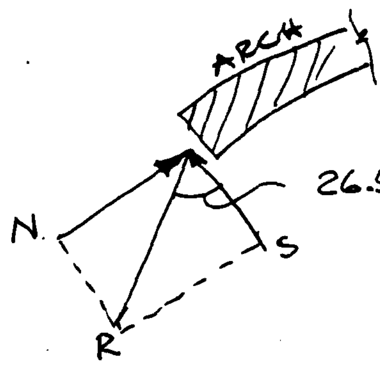
$$H = 1397 \text{ in} \cdot 156 \frac{\text{lb}}{\text{in}} \cong \underline{\underline{218 \times 10^3 \text{ lbs}}}$$

$$V = \frac{qL}{2} = \frac{1872 \times 136'}{2} = 127 \times 10^3 \text{ lbs}$$

RESULTANT $R = \sqrt{H^2 + V^2} = 252 \times 10^3$ lbs.



$$\theta = \sin^{-1}\left(\frac{127}{252}\right) = 30.3°$$



$26.5° + 30.3 \cong 56.8°$
$\approx 57°$

SHEAR $= R \cos 57° = 138 \times 10^3$ lbs

NORMAL $= R \sin 57° = 211 \times 10^3$ lbs

D'APPOLONIA
CONSULTING ENGINEERS, INC.

By BE Date 7/24/81 Subject BEEBE LAKE DAM Sheet No. 6 of 8
Chkd. By J.A.E. Date 8/5/81 STABILITY CALCULATIONS Proj. No. 80-778

CHECK ABUTMENT STRESSES UNDER 100% PMF LOADING

$$\text{SHEAR} = \frac{138 \times 10^3 \text{ lbs}}{1728 \text{ in}^2} = 80 \text{ psi.}$$

$$\text{COMPESSION} = \frac{211 \times 10^3}{1728 \text{ in}^2} = 122 \text{ psi.}$$

VISUAL OBSERVATIONS AT THE SITE INDICATE THAT FOUNDATION ROCKS ARE SAND & LIMESTONES

ACCORDING TO ETL 1110-2-184 Feb 25, 1974 AVERAGE LOWER BOUND SHEAR STRENGTH OF CALCAREOUS & SEDIMENTERY ROCKS ARE :-

CALCAREOUS : ϕ : 45° S: SHEAR STRENGTH = 500 psi
SEDIMENTARY : ϕ : 47° S: " " = 500 psi
(EXCEPT SHALES)

FACTOR OF SAFETY AGAINST ABUTMENT SLIDING :
SAY $\phi = 45°$ S = 500 psi

$$R = \Sigma V \tan\phi + sA$$
$$= 21B \times 10^3 \tan 45° + 500 \times 1728$$
$$= 233 \times 10^3 + 864 \times 10^3 \text{ Lbs.} = 1075 \times 10^3$$

$$S_{s\text{-}f} = \frac{R}{\text{SHEAR FORCE}} = \frac{1075 \times 10^3}{138 \times 10^3} = 7.8 \quad 7\ 4 \quad \underline{\underline{ok}}$$

COMPRESSION 135 psi OK BY INSPECTION.

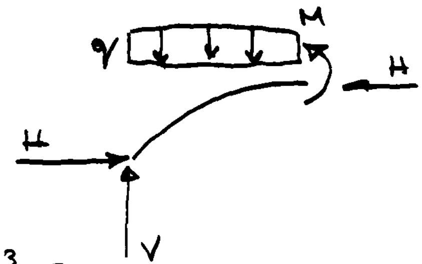
CHECK MID SPAN STRESSES:

$$M = \frac{qL^2}{8} - Hf \qquad f = 16'$$

$$= \frac{156 \text{ lb/in } \overline{136 \times 12}^2}{8} - 218 \times 10^3 \times 16 \times 12$$

$$= 51.9 \times 10^6 - 41.8 \times 10^6 \text{ in-lb}$$

$$= 10.1 \times 10^6 \text{ in-lbs.}$$



$$\sigma = \frac{H}{A} \pm \frac{M}{S} \qquad S = \frac{bh^2}{6}$$

$b = 12"$ $h = 144"$ $S = 41.5 \times 10^3 \text{ in}^3$

$$\sigma = \frac{218{,}000}{1728} \pm \frac{10.1 \times 10^6}{41.5 \times 10^3} = 126 \pm 243$$

TENSION = 117 psi COMPRESSION = 369 psi

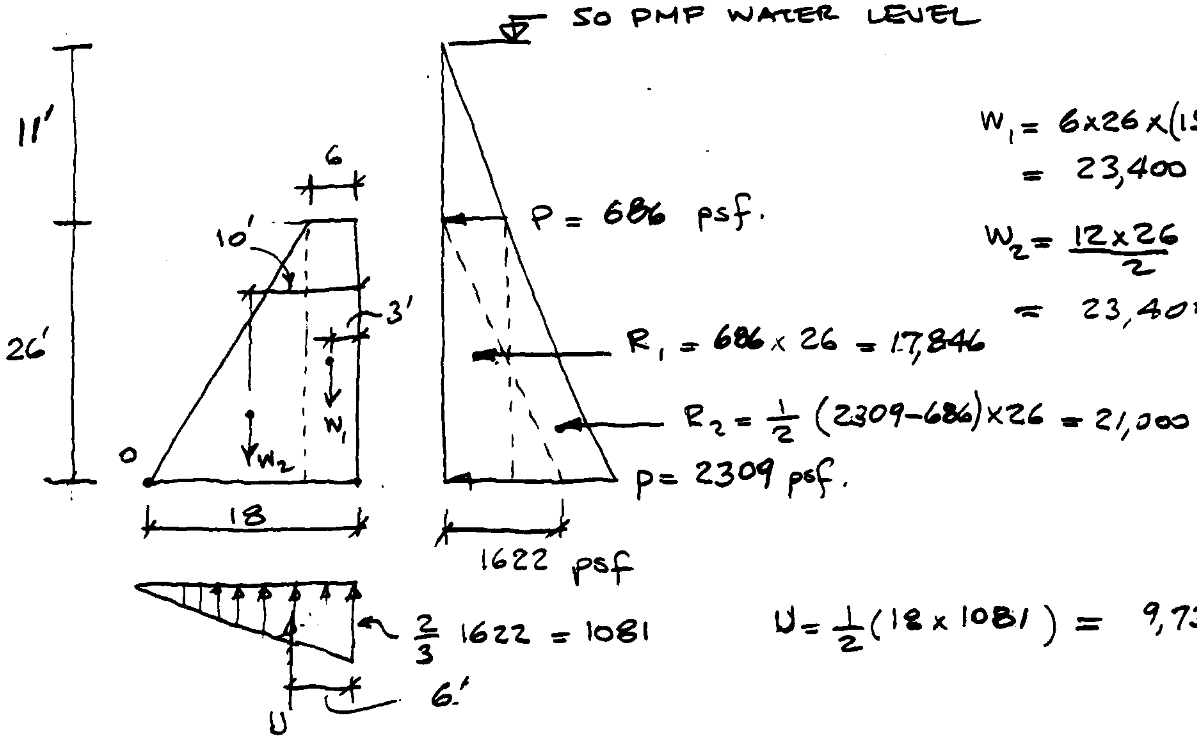
ASSUMING DAM CONCRETE TO BE $f_c' = 3000$ psi.

ULTIMATE TENSILE STRENGTH: $f_r = 7.5\sqrt{f_c'}$ ACI-318-71 9.5.2.2

$f_r = 410$ psi > 117 psi $\therefore$ OK

CHECK STABILITY ASSUMING THE DAM TO BE
A GRAVITY STRUCTURE

LOADING : 50 % PMF OVERTOPPING: 11 ft.



$W_1 = 6 \times 26 \times (150\ lb/ft^3)$
$= 23,400$ lbs

$W_2 = \frac{12 \times 26}{2}\ (150\ lb/ft^3)$
$= 23,400$ lbs

$U = \frac{1}{2}(18 \times 1081) = 9,735$ lb.

MOMENTS ABOUT PT 'O'

$$M = 15\,W_1 + 8\,W_2 - 12\,U - 13\,R_1 - \frac{26}{3}\,R_2$$
$$= (351 + 187 - 117 - 232 - 183) \times 10^3 \text{ ft-lbs}$$
$$= (538 - 532) \times 10^3 = 6 \times 10^3 \text{ lb-ft.}$$

BY INSPECTION THE RESULTANT OF THE FORCES FALLS OUT OF THE MIDDLE 1/3 OF THE BASE ∴ THE DAM MAY BE UNSTABLE.

APPENDIX I

REFERENCES

APPENDIX I

REFERENCES

Broughton, J. G., D. W. Fisher, Y. W. Isachsen, and L. V. Rickard, 1966, "Geology of New York," New York State Museum and Science Service, Educational Leaflet 20, 50 pp.

Fisher, D. W., Y. W. Isachsen, and L. V. Rickard, 1971, "Generalized Tectonic-Metamorphic Map of New York," New York Museum and Science Service, Map and Chart Series No. 15.

Flint, R. F., 1971, Glacial and Quaternary Geology, John Wiley and Sons, Inc., 892 pp.

Rickard, L. V. and D. W. Fisher, 1970, "Geologic Map of New York, Finger Lakes Sheet," New York State Museum and Science Service, Map and Chart Series No. 15.

Thornburg, W. D., 1965, Regional Geomorphology of the United States, John Wiley & Sons, Inc., 609 pp.

U.S. Army Corps of Engineers, 1956, Hydrometeorological Report No. 33.

U.S. Department of Commerce, 1965, Weather Bureau Hydrometeorological Report No. 40.

U.S. Department of the Interior, Bureau of Reclamation, 1974, Design of Small Dams.

Wright, H. E., Jr. and D. G. Frey, 1965, The Quaternary of the United States, Princeton University Press, 922 pp.